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NEXT GENERATION LABS

DL NGL-IOT

Module for the study of the Internet of Things

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The term "Internet of Things" identifies a system in which not only people are able to connect to a Global Network, but also the most common objects.

These objects can be seen and controlled both by other objects and by network users.

There is no limitation to the type of object that can be connected, thus providing the Internet of Things with an unlimited space of applications: industry, home automation, medicine, etc.

The 'IoT' Module adds to the Basic Module the devices and tools for the study and learning of all topics related to the Internet of Things.

With this module you can acquire skills on all issues related to the IoT world:

- Characteristics and performance of the devices to be connected: sensors, actuators, etc.
- Communication technologies: protocols, networks, etc.
- Information technologies: server, database, client, etc.
- Analysis of performance, safety, etc. of the system.

The Module consists of devices and tools to set up a complete IoT system, where to carry out all the exercises and experiments:

- **DevIoT Unit,** with sensors, actuators and connection interfaces to wired and wireless networks. It is supplied with Firmware for immediate use, but it is also programmable via the Arduino development platform to allow users to develop customized applications.
- **IoT Server and Client** (with MQTT protocol).
- **Service tools** for testing and functional analysis: protocol analysers, Wi-Fi analysers, network traffic meters, etc.

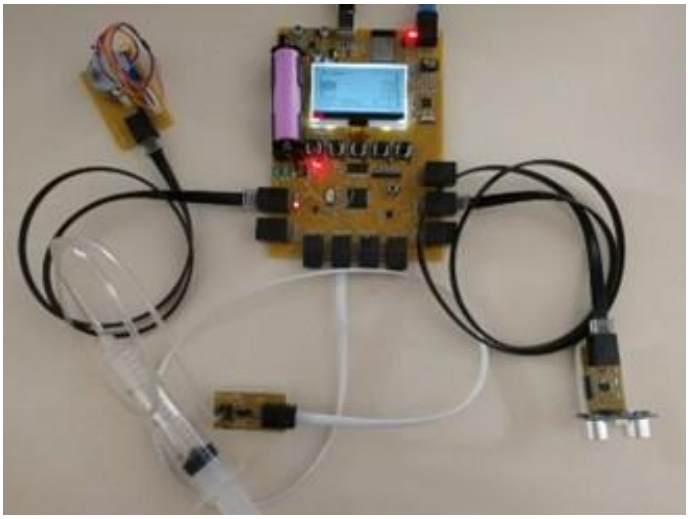
The figure shows the laboratory network and how the devices of the IoT Module find their space within it to provide a complete system that represents a real IoT application.

The IoT Module can be integrated with the miniSim series Simulators that allow studying different IoT applications:

- Energy
- Agriculture
- Chemistry
- Biomedical
- Manufacturing
- Automotive

Through the tools made available, they reproduce complete IoT systems in a single workstation, in an 'open' form, where the student can therefore interact independently with the different parts of the system in learning operations, at any level.

Devices and tools are described below.



- **DevIoT Unit:**
  - Rechargeable battery powered via USB (5V)
  - Microcontroller STM32F103
  - Display LCD 128x64, 5-key keyboard
  - USB interface
  - Compatibility with Arduino development platform
  - LAN Ethernet 100Mb/s interface
  - Wi-Fi network interface
  - 4 interfaces for analogue sensors
  - 3 interfaces for digital sensors
  - 2 interfaces for actuators
- **Sensors and actuators to be connected to the DevIoT Unit:**
  - Sensors:
    - PT100 temperature analogue sensor
    - Pressure analogue sensor
    - Force analogue sensor
    - Brightness digital sensor
    - Ultrasonic distance digital sensor
    - Acceleration digital sensor
    - ON-OFF inputs sensor
    - Heart rate sensor
  - Actuators:
    - DC motor
    - Step motor
    - ON-OFF outputs

MQTT (IoT) Broker and Client and Service Tools

An IoT application is basically a 'distributed' application. where the various components of the system (sensors, servers, clients, actuators, etc.), located in different places, communicate with each other through the Internet. Reproposing distributed systems of this type at an educational level, where the student, in order to be able to learn, must see inside the system how information passes from one component to another, is impossible using directly Servers available online on the Internet with their hosting services. For this reason, the IoT Module is equipped with software to implement IoT Server (Broker) and Client, integrated in the DL WORKSPACE environment, and, therefore, usable on all workstations.

All this allows each Student, with the resources of his own workstation, to set up a complete IoT System and to experiment on it at any level. He is, therefore, enabled to learn the various problems that underlie systems of this type, working autonomously on his own workstation and proceeding at his own learning speed.

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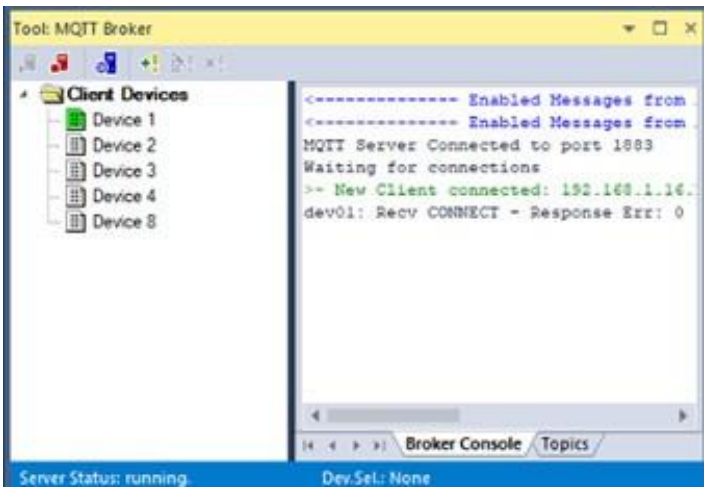
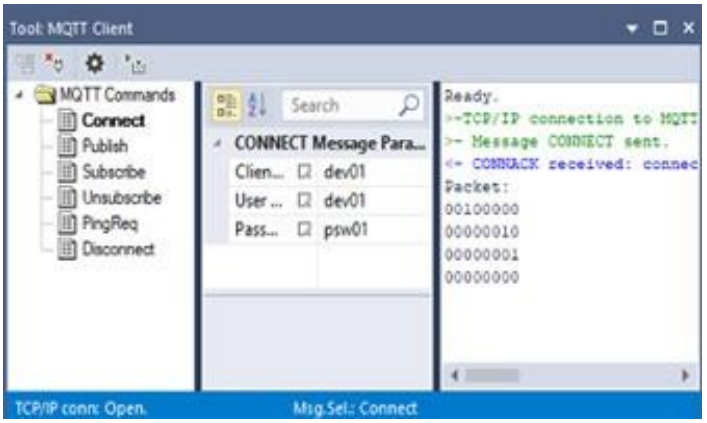
MQTT Broker

DL WORKSPACE provides an MQTT Broker for all exercises related to the IoT. This is the indispensable tool for connecting the various devices of the system to each other. The Broker is equipped with a Database where the devices and the parameter values that they publish on the network are stored. The Broker Console displays all the information that passes through the Server, thus allowing the student to analyse in detail the operation of the system.



MQTT Client

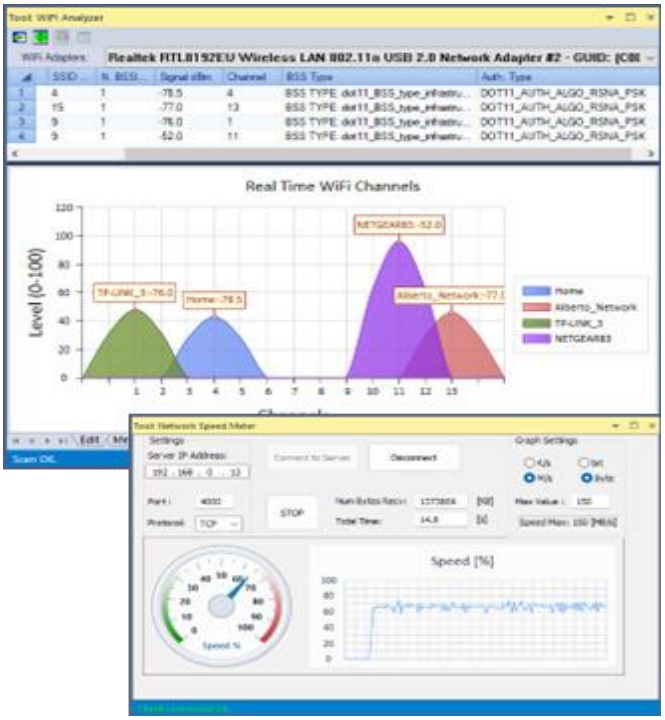
The DL WORKSPACE also integrates an MQTT Client, widely used in carrying out the experiments. The Client allows you to connect to a Broker and manually set all the commands of the MQTT Protocol that allow communication. In this way, the student can analyse in detail all the characteristics of the protocol which underlies the IoT.



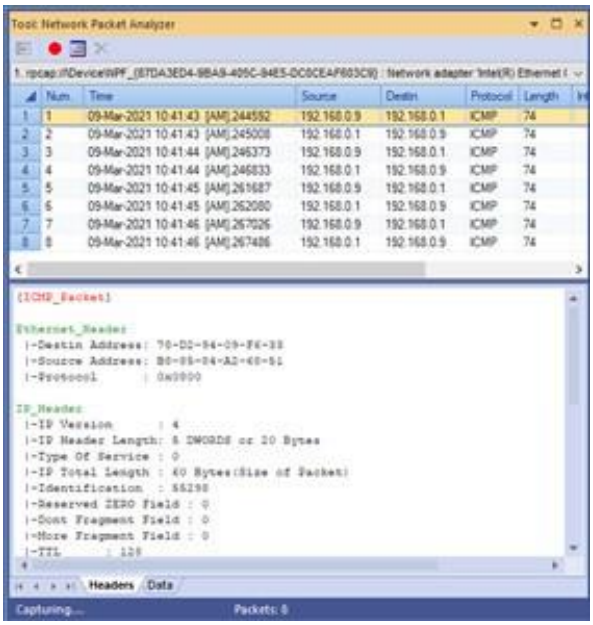
Among other service tools that are used in the exercises we have:

The **Wi-Fi Network Analyzer**, which allows detecting the networks present in the area of interest and checking all the parameters, including the level of the signal, the frequencies and the channels used.

The **Network Speed Meter**, which allows checking the performance of a network in terms of data transfer speed.



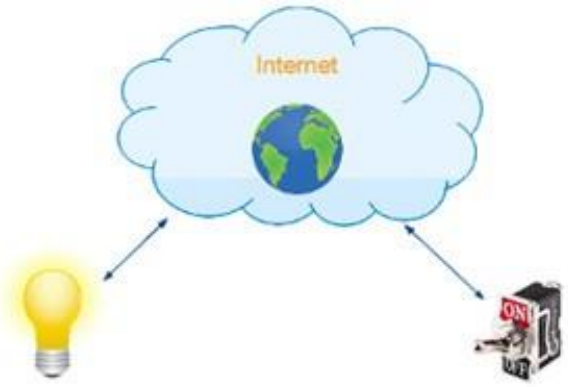
The **Network Packet Analyzer** (or Packet Sniffer), a software tool that allows capturing and analysing packets traveling on a network. This tool is commonly used in network testing operations, but can also be used by hackers to capture 'sensitive' user data.



All the above tools make the IoT Module an effective tool for studying the Internet of Things and its applications.

The following notes, taken directly from an exercise in the manual, are an example.

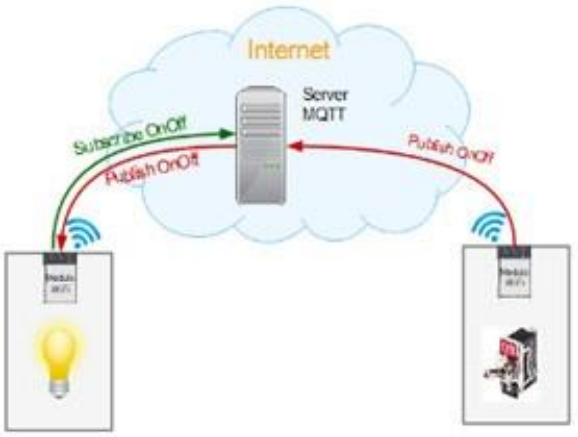
Suppose we want to study the functioning of an IoT system where a 'switch' object (placed anywhere in the world) controls a 'lamp' object (placed anywhere else in the world) via the Internet of Things.



The 'real system' that implements the above system, with its components, is shown in the figure.

Each of the two devices (switch and lamp) must be equipped with a Wi-Fi module that transmits or receives information from an MQTT server located anywhere on the Internet.

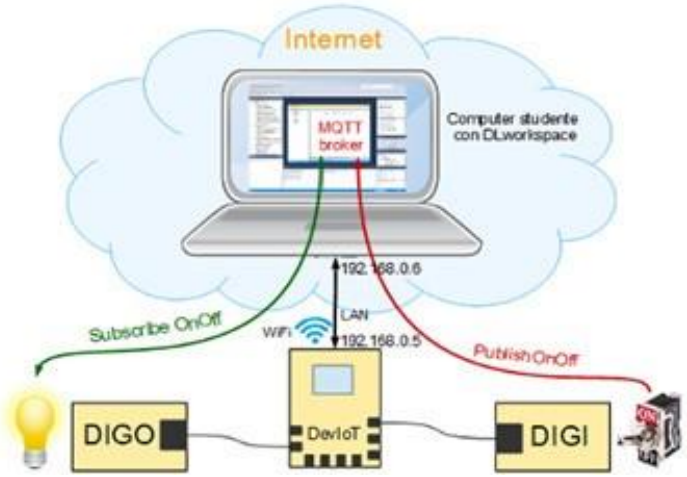
The "switch module" publishes its On/Off status on the server via the topic 'OnOff'. The "lamp module" subscribes to the switch's 'OnOff' topic on the MQTT server and receives its status every time it changes.



The previous 'real system' can be implemented, within the IoT Module of the DL NGL Laboratory, using a single workstation. The student uses:

- a DIGI digital sensor
- a DIGO on/off actuator
- a DevIoT Unit, LAN o Wi-Fi connected to its own PC
- the MQTT Server/Broker on the PC

All the experiments on the system are widely documented in the DL WORKSPACE.



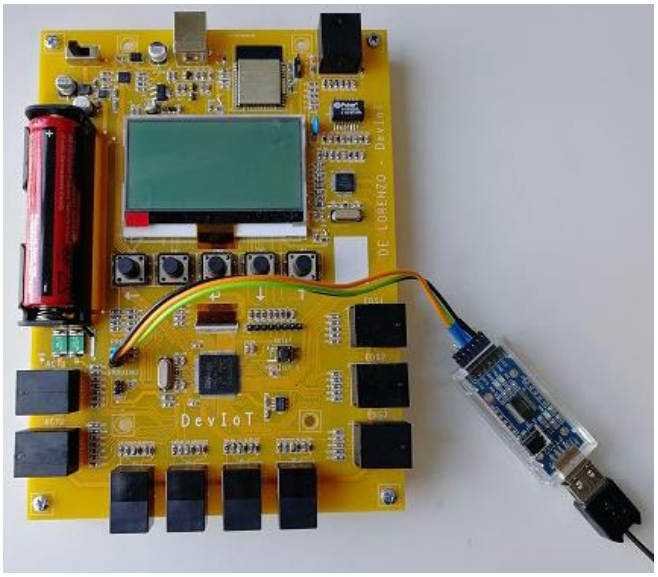
Use with the Arduino development platform

The DevIoT Unit is equipped with a Firmware that allows its use in all the applications.
This firmware provides to:

- the automatic detection of connected sensors and transducers,
- the experimentation of the operation of each of them,
- the connection with an MQTT Broker for the applications related to the Internet of Things,
- the management of the miniSim with all the exercises,
- the connection via USB to the computer for parameter setting and supervision operations,
- the keyboard, display and battery management.

The STM32F103 Microcontroller can also be programmed via the Arduino Platform, using a serial interface (UART) of the microcontroller and a Serial-USB adapter (supplied) for connection to the computer.

The figure shows the connection of the serial adapter for developing applications with Arduino.



C++ libraries are provided for managing all board resources:

- 128x64 graphic LCD display,
- SPI interface with external digital sensors,
- Ethernet interface,
- Wi-Fi interface,
- etc.

Simple examples of the use of each of the board's functions are also reported in the documentation.

'Basic' didactic program

- Introduction to IoT
  - Definition of an IoT system.
  - Fields of application: industrial, safety, health, home automation, etc.
  - Structure of an IoT system and its components: sensors, actuators, networks, protocols, etc.
  - Server and client: user interfaces.
  - Future issues and developments.
- Sensors, transducers and actuators
  - Sensors for acquiring the physical quantities to be controlled.
  - Actuators for commanding and regulating physical quantities.
  - Microprocessor acquisition and control unit.
  - The problems of remote control and supervision.
- Structure of an IoT network
  - The Client-Server structure.
  - The MQTT protocol: message publishing and subscription.
  - MQTT Client and Server.
- Application examples
  - Remote sensing of environmental parameters: temperature, humidity and pressure.
  - Safety systems: distance detection of objects with ultrasound system.
  - Remote control of industrial devices: motors, actuators, etc.
  - Home automation: command and control devices.
  - Telemedicine: remote detection of physiological parameters.

'Advanced' didactic program

- Introduction to IoT
  - Definition of an IoT system.
  - Fields of application: industrial, safety, health, home automation, etc.
  - Structure of an IoT system and its components: sensors, actuators, networks, protocols, etc.
  - Server and client: user interfaces.
  - Future issues and developments.
- Control and supervision of industrial processes.
  - Sensors for acquiring the physical quantities to be controlled.
  - Actuators for commanding and regulating physical quantities.
  - Microprocessor acquisition and control unit.
  - Firmware development on Arduino platform.
  - Wired and wireless networking of devices.
  - The problems of remote control and supervision.

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- Structure of an IoT networks, communication devices and protocols
  - The structure of the Internet network. o Network connection devices: routers, switches, access points, etc.
  - Communication protocols: the OSI Model.
  - MQTT protocol: message publishing and subscription.
  - HTTP protocol. o Security issues.
- Server, database and Client
  - Structure of an MQTT Broker.
  - Structure of an HTTP Server.
  - Database SQLite.
  - Development of Web Client applications: languages HTML, JavaScript.
- Application examples
  - Remote sensing of environmental parameters: temperature, humidity and pressure.
  - Safety systems: distance detection of objects with ultrasound system.
  - Remote control of industrial devices: motors, actuators, etc.
  - Home automation: command and control devices.
  - Telemedicine: remote detection of physiological parameters.

NEXT GENERATION LABS

The DL NGL-IOT module can be integrated in the DL NGL - NEXT GENERATION LAB laboratory through the minimum purchase of the following modules:

- **Teacher Station - DL NGL-BASE**
  Necessary for the proper functioning of the laboratory. Quantity: 1.

- **Student Station - DL NGL-STUDENT**
  To be multiplied by the number of "student stations" to be created.